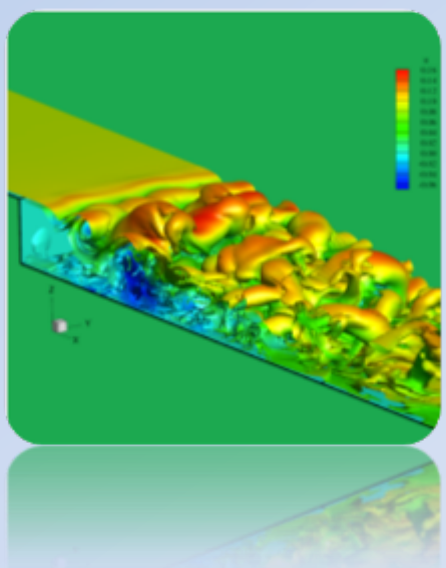
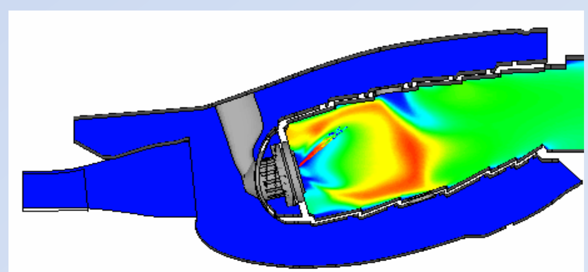
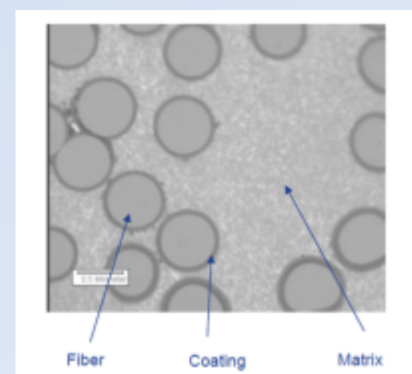
NASA ARMD LEARN/Seeding Seminar
Models to Manufacturing
January 14, 2015

Jim Heidmann

Manager, Transformational Tools & Technologies Project







NASA Aeronautics Research Six Strategic Thrusts

Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles
- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

How are the vision's research thrusts used?

All of the new programs address more than one, or all, of the research thrusts.

MISSION PROGRAMS

Airspace Operations and Safety Program

AOSP

Safe, Efficient Growth in Global Operations

Real-Time System-Wide Safety Assurance

Assured Autonomy for Aviation Transformation

Advanced Air Vehicles Program

AAVP

Ultra-Efficient Commercial Vehicles

Innovation in Commercial Supersonic Aircraft

Transition to Low-Carbon Propulsion

Assured Autonomy for Aviation Transformation

Integrated Aviation Systems Program

IASP

Flight research-oriented, integrated, system-level R&T that supports all six thrusts

X-planes/ test environment

SEEDLING PROGRAM

Transformative Aeronautics Concepts Program

TACP

High-risk, leap-frog ideas that support all six thrusts

Critical cross-cutting tool development and advancement of critical aeronautics technologies

Transformational Tools & Technologies (T^3) Project

What is the Transformative Aeronautics Concept Program?

While mission programs focus on solving challenges, this program focuses on cultivating opportunities.

Seedling Program

Transformative Aeronautics Concept Program

Cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation and harnesses convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation

Knocks down technical barriers and infuses internally and externally originated concepts into all six strategic thrusts identified by ARMD, creating innovation for tomorrow in the aviation system.

Provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation.

Solicits and encourages revolutionary concepts

Creates the environment for researchers to become immersed in trying out new ideas

Performs ground and small-scale flight tests

Drives rapid turnover into new concepts

Projects

Leading Edge Aeronautics Research for NASA (LEARN)

Transformational Tools & Technologies

Convergent Aeronautics Solutions

Transformational Tools & Technologies (T³) Project

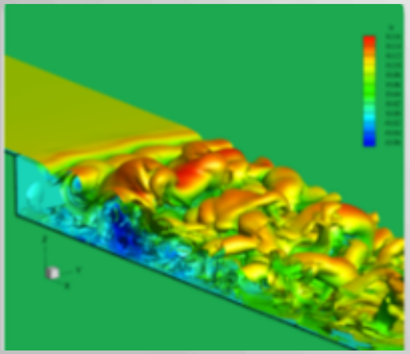
Enable fast, efficient design & analysis of advanced aviation systems from first principles by developing physics-based tools/methods & cross-cutting technologies, provide new MDAO & systems analysis tools, & support exploratory research with the potential to result in breakthroughs

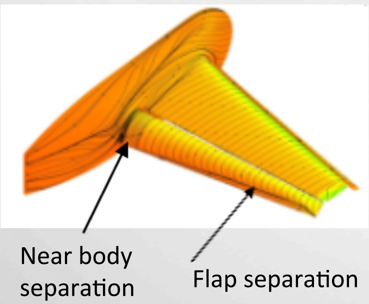
Vision

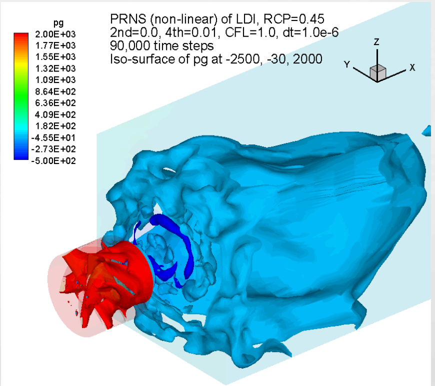
- Physics-based predictive methods for improved analysis and design
- Leverage improved understanding and discipline integration toward improved future air vehicles

Scope

- Foundational research and technology for civil air vehicles
- Discipline-based research and system-level integration method development



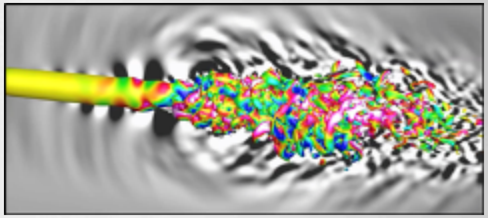


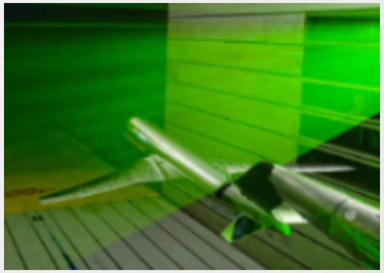


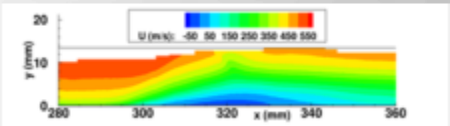
Revolutionary Computational Aerosciences

Goal:

- Identify and downselect critical turbulence, transition, and numerical method technologies for 40% reduction in predictive error against standard test cases for turbulent separated flows, evolution of free shear flows and shock-boundary layer interactions on state-of-the-art high performance computing hardware. Capability will be used by the aeronautics community to improve designs and reduce design cycle times. Facilitates accelerated introduction of advanced air vehicles and propulsion systems into the airspace system.







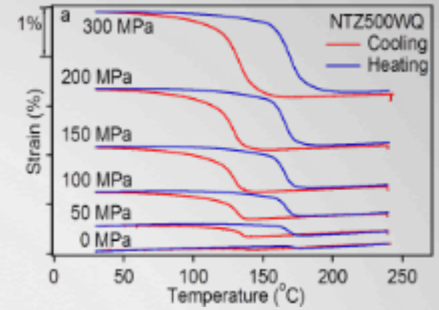
Approach:

- Development of more accurate physics-based methods (e.g. higher moment closure, large eddy simulation (LES))
- Advanced numerical methods
- Transition prediction and modeling
- Validation experiments
- Multidisciplinary analysis and design (high fidelity)

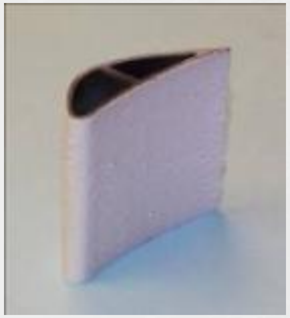
Structures and Materials

Goals and Approaches:

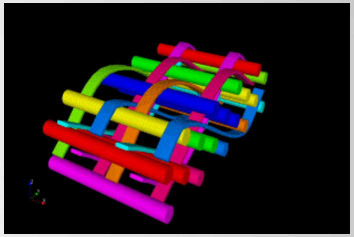
- Develop **multi-functional structures & materials** that reduce weight and enable innovative components by meeting multiple airframe or engine requirements simultaneously
- Develop **high temperature engine materials** and associated design and life prediction tools to reduce or eliminate the need for turbine cooling and reduce weight
- Develop physics-based **computational design and optimization** capability for airframe and engine materials and structures



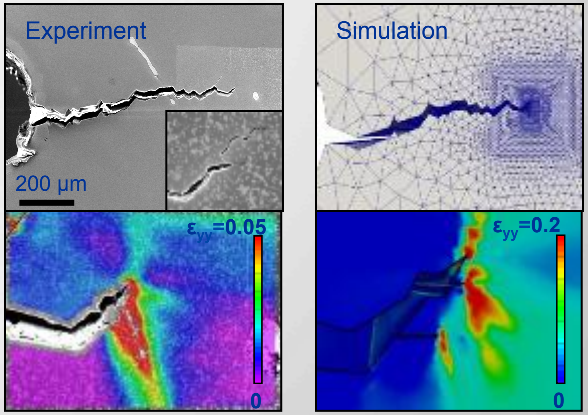
Shape-Memory Alloys



EBC-Coated CMC Vane



Advanced 3D Fiber Architecture



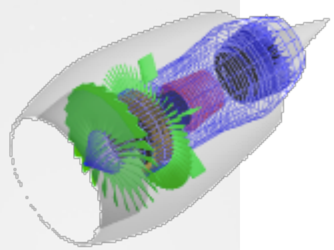
Computational Materials

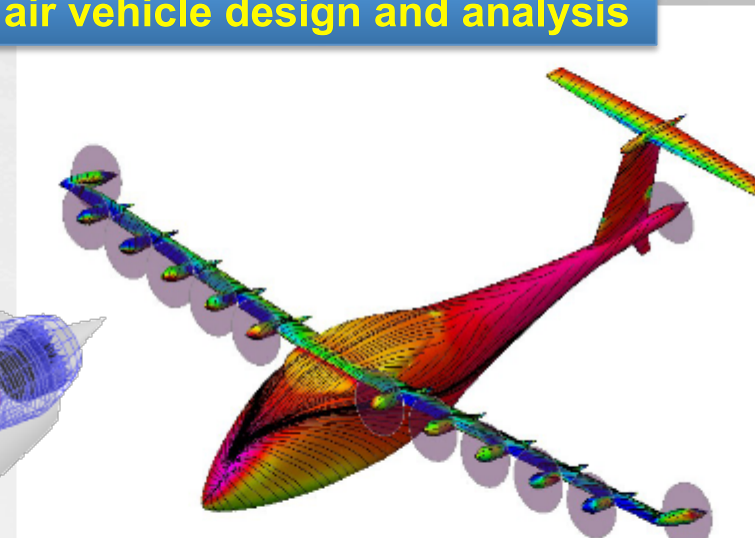
MDAO & Systems Analysis

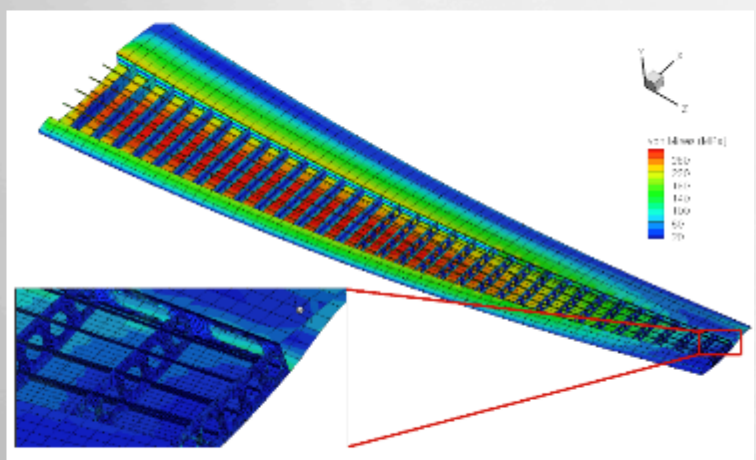
Tool development at multiple levels of fidelity for air vehicle design and analysis

Goal:

- Develop MDAO architectures and frameworks to solve complex optimization problems
- Improve upon the existing toolsets for the conceptual design and analysis of conventional and unconventional aircraft for the Fundamental Aeronautics Program at NASA







Approach:

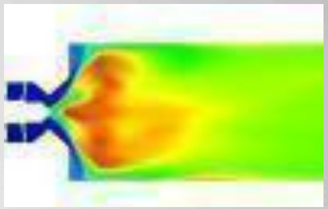
- Develop MDAO capabilities of the OpenMDAO framework and algorithm toolset
- Improve the flexibility and fidelity of parametric geometry modeling for input to high fidelity discipline tools
- Enhance and/or develop individual and multi-disciplinary tools at multiple levels of fidelity focused on conceptual design and analysis
- Develop advanced acoustic analysis and design optimization tools for MDAO.
- Use challenge problems to focus development and demonstrate capabilities

Combustion

Develop and validate physics-based combustion models, perform fundamental experiments and investigate new combustor technologies

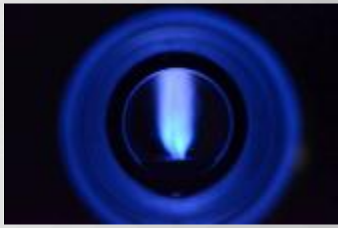
Goal:

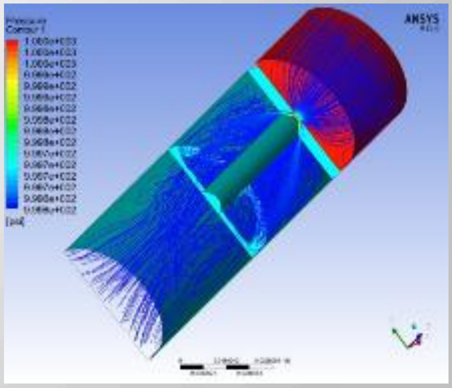
- Provide improved computational tools and critical technologies to enable combustor concepts that meet NASA fuel burn and emissions goals for future aircraft engines.



Approach:

- Develop and validate physics-based combustion models for CFD. Develop capability for tightly coupled combustor-turbine simulations
- Perform experiments to provide high-quality CFD validation data at relevant combustor conditions (fuel, pressure, temperature)
- Perform experiments with detailed diagnostics to provide a fundamental understanding of low-emission systems
- Develop and test critical combustion control technologies (passive and active) for future lean burn combustors
- Explore innovative combustor technologies (such as Pressure Gain Combustion)





Flight & Propulsion Controls

Goal: Develop tools and technologies that enable aircraft and propulsion systems to operate at their maximum efficiency and capability under all conditions.

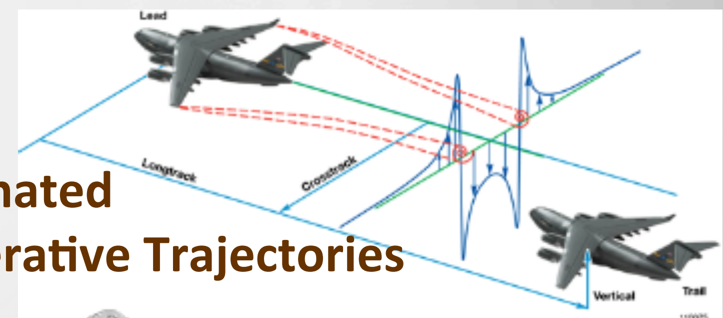
Flight Controls Approach:

- Learn to Fly – to rapidly design and validate vehicle control using automation and self-learning.
- Automated Cooperative Trajectories – to provide the vehicle level systems that enable the fuel savings of formation flying.

Propulsion Controls Approach:

- Distributed Engine Control – to enable performance & efficiency improvement and eliminate constraints on the engine system.

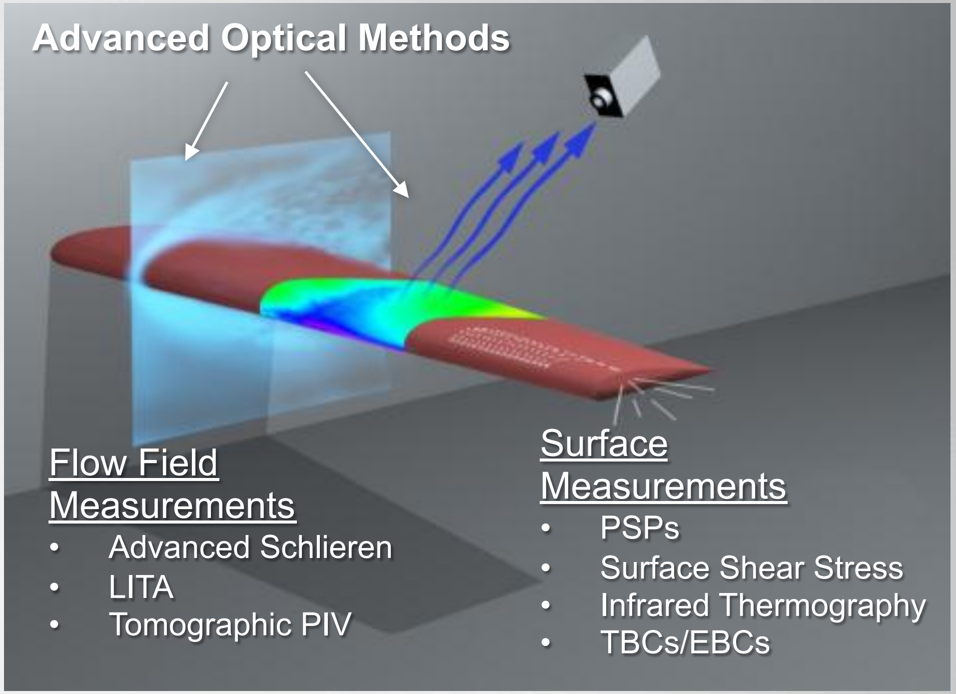
Automated Cooperative Trajectories



Distributed Engine Control

Innovative Measurements

Goal:
Measurement science technologies have limited fidelity, robustness, and range of applicability. Seek to overcome these limitations and enable new methods for obtaining critical experimental data for validation of computational methods and for diagnostics of airframe and engine components.



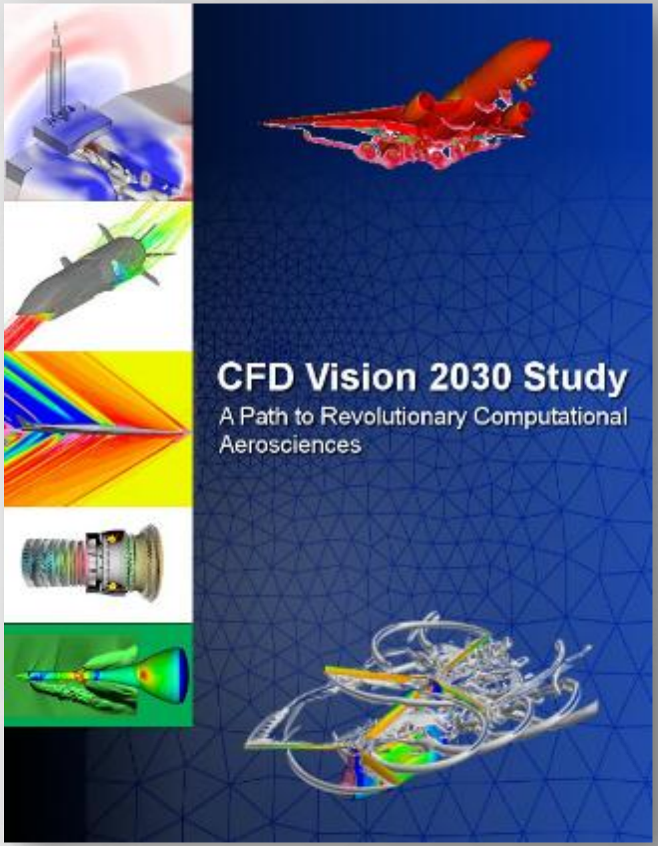
Approach:
- Developing flow field and surface measurement techniques which extend the state-of-the-art
- Leveraging center expertise from all four research centers to produce integrated instrumentation approaches.
- Emphasize linkages/partnerships within T^3 and with FA projects to fully establish the critical need for this work.
- Partner with ATP to coordinate investments.

CFD Vision 2030 Study

- CFD technology roadmap developed, including HPC, physical modeling and numerical algorithms for a validated, physics-based multidisciplinary analysis and design capability for the notional year 2030.
- Wide community support for the research roadmap, as evidenced by articles in Aviation Week & Space Technology, The Connector, Science Daily as well as speaking invitations from DoE and Pointwise.

FY14 Milestones/Accomplishments

- Final NRA Review, 11/14/2013.
- Roadmap for Vision 2030 CFD technology developed, 3/31/2014.
- Wide CFD community support for the roadmap at the AIAA Aviation 2014 Panel Discussion, 6/16/2014.



NASA CR 2014-218178

Report available at: http://www.aeronautics.nasa.gov/fap/tech_highlight_aero6.html

Transformational Tools & Technologies (T^3) Project Management Structure*

PROJECT LEVEL

Executive Team:
Project Manager – Jim Heidmann (GRC)
Deputy Project Manager – Dan Williams (LaRC)
Associate Project Manager – Mike Rogers (ARC)

Center Liaisons
(AFRC, ARC, GRC, LaRC)

Business Team

SUB-PROJECT

Revolutionary Tools & Methods (RTM)

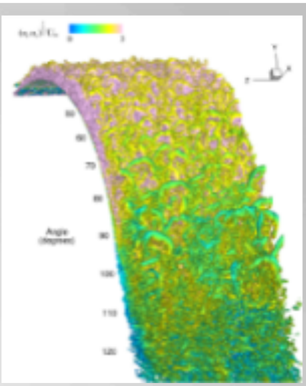
Development of revolutionary comprehensive physics-based aeronautics analysis and design capability. Philosophically based on Vision 2030 study recommendations. Current Technical Challenge to reduce CFD error by 40% by 2017.

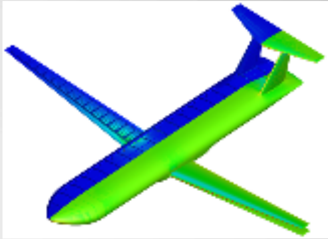
Critical Aeronautics Technologies (CAT)

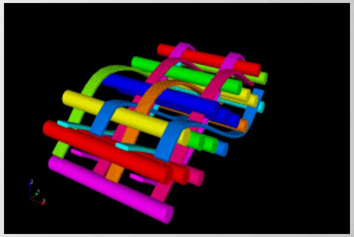
Development of critical aeronautics technologies that can enable revolutionary improvement in aircraft system design. Innovative ideas that may lead to patentable results. Current Technical Challenge to develop 2700°F-capable engine materials by 2017.

*Transition to this structure during FY15

T^3 Project Summary







- Exciting suite of fundamental, cross-cutting research
- Developing and validating critical tools, models and technologies for application to other NASA projects and the broader aeronautics community
- Focused on two major areas – future modeling and design capability and critical innovative technology development – FY15+ direction
- Leveraging external collaborations to augment and complement in-house research efforts

Opportunities on the horizon for key advances in Aeronautics Tools and Technologies!

http://www.aeronautics.nasa.gov/fap/aeronautical_sciences.html

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